PROGRESS REPORT 4:

"CORTICAL CONTROL OF NEUROPROSTHESES"

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This progress report covers: 1- efforts to prepare manuscripts detailing our recent work on this contract, 2- recent analyses of motor tuning functions in the MI cortex, and their relation to neural population control of external motion devices, 3- progress in developing a neuroprosthesis paradigm for the monkey, 4- progress in developing a computer based real-time interface for neuroprostheses.

1- Preparation of manuscripts detailing our recent work on this contract.

Manuscripts are being prepared to publish the work on this contract recently carried out in the labs at Allegheny University of the Health Sciences and Duke University. At Allegheny, a manuscript is being prepared to report the recent feasibility demonstration of cortical control of a robot arm using the rat model. At this time, 8 rats have been utilized in this study. Five have successfully used neural population activity to control the robot arm; Three of these used forelimb-movement related activity for this control, while two used mouth-movement related activity. (The latter were used in an initial investigation into the dissociability of the cortical signal from the overt movements normally associated with it.) Two animals are currently being studied in the laboratory.

Another manuscript, currently in the revision stage, details the recent work at Duke. It reports on successful recordings of large numbers (>100) of neurons in the monkey sensorimotor cortex, and the relationship of these neurons to movement and somatosensory feedback.

2- Analysis of motor coding properties of neurons in the rat MI cortex

As part of the data analysis required for publication of the rat data, we are analyzing the codign relation of each of our recorded neurons with movements across each of the three major joints in the upper extremity, i.e. the shoulder, elbow and wrist joints. These analyses involve correlating nerual activity around movement information derived from three sources, including: a) continuous records of manipulandum movements, b) frame-by-frame analyses of synchronized video recordings we have made of all our experiments, and c) EMG recordings obtained from various forelimb muscles during these same experiments. One reason for addressing this issue is the general finding that the different recorded neurons exhibit a complex range of responses over the forelimb movement trajectory. We reasoned that some this complexity might be explained as a summation of cortical neuronal representations of movements across the shoulder, elbow and wrist joints, all of which are used in the manipulandum movement. We found this hypothesis to be only partially true: the neuronal activites were generally found to be related less to movements around individual joints, or to specific forelimb muscles, than to the spatiotemporal properties of the movement trajectory as a whole. Based on this general observation, we are now undertaking a more quantitative analysis of the issue of motor coding in the context of forelimb movement trajectories.

3- Monkey Recordings.

Further progress has been made in Dr. Nicolelis' lab at Duke University in gearing up for appropriate experiments in the monkey. Working with Dr. Amy Brisben, a post-doc being paid by this contract, Dr. Nicolelis has successfully implemented a device for real-time monitoring of the movements of multiple joints of the monkey's arm in three dimensions. This

involves sensors mounted on the skin surface. This will provide the signal for forelimb directed movement of a robot arm from a water or food source to the monkeys mouth. Progress on the technical side toward developing this paradigm is further discussed below.

4- Development of computer based real-time interface:

Further progress has been made at Plexon Inc. in development of a Windows NT version of their multi-neuron acquisition software/hardware system. This is important because this version will allow simultaneous execution of multiple tasks, employing the internal client-server features in the new NT OS. Plexon hopes, by January, 1998,. to be able to set up a server to monitor the on-line discrimination of brain neurons, and feed this information in real-time to multiple clients, including on-line analysis applications, on-line statistical or neural network appliactions, and from there to on-line robotic control applications. Even though Windows NT is not a true real-time OS, it should work well within the time constraints in this application. Currently, the plan for controlling the motion devices is to utilize National Instrument's LabView-LabWindows package, which allows easy graphical programming of IO devices, and any conceivable transformation between them. Most of the available robotic systems interfaces provide drivers for control through LabView. This plan provides the laboratory investigators maximal flexibility in their experimentation with different schemes for transforming the cortical signals to motion system (of FNS) outputs. When and if this experimentation successfully identifies optimal transformation algorithms, they can be more compactly encoded into microelectronic systems with better real-time response.